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Code 427

LANDSAT DATA CONTINUITY MISSION

LDCM SPACECRAFT
STATEMENT OF WORK (SOW)

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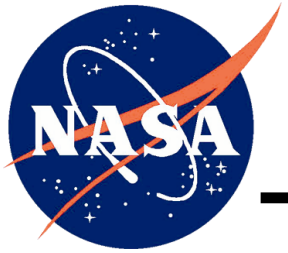

Goddard Space Flight Center
Greenbelt, Maryland

National Aeronautics and Space Administration

CM FOREWORD

This document is a Landsat Data Continuity Mission (LDCM) Project Configuration Management (CM)-controlled document. Changes to this document require prior approval of the applicable Configuration Control Board (CCB) Chairperson or designee. Proposed changes shall be submitted to the LDCM CM Office (CMO), along with supportive material justifying the proposed change. Changes to this document will be made by complete revision.

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LDCM PROJECT
DOCUMENT CHANGE RECORD

Sheet: 1 of 1

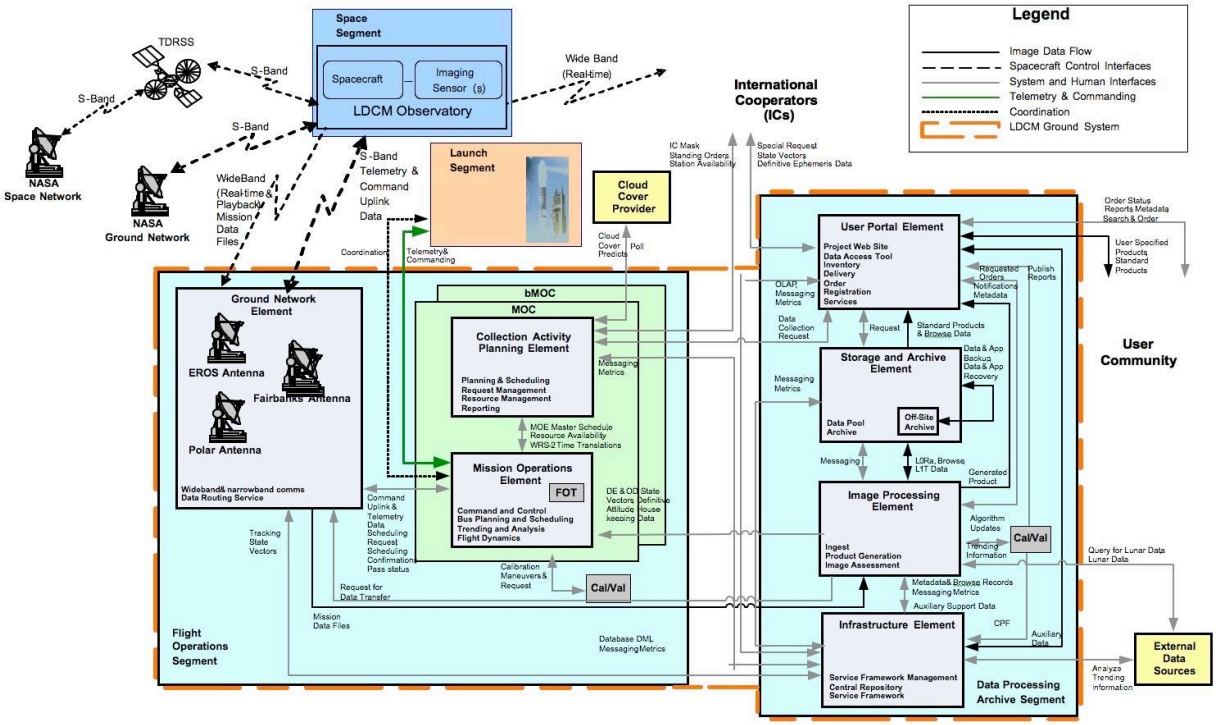
REV. LEVEL	DESCRIPTION OF CHANGE	DATE APPROVED
Rev -	Baseline Release. Approved by CCR 427-07-06-005.	12/07/07

TABLE OF CONTENTS

1.0 Introduction

This SOW defines the work requirements for the Spacecraft implementation and Observatory integration for the Landsat Data Continuity Mission (LDCM). The block diagram shown in Figure 1-1 identifies the segments, systems, and elements required to accomplish the mission.

FIGURE 1-1
LDCM BLOCK DIAGRAM



The following is an overview of the work summary, launch, instrument(s), mission partners, non-disclosure agreements, and terms and definitions. This introduction relates the Contractor's work to the LDCM mission. This section *1.0 Introduction* contains no Contractor work requirements.

1.1 Work Summary

This Statement of Work (SOW) defines the Contractor's efforts required to implement the Observatory portion of the Landsat Data Continuity Mission (LDCM). These efforts include:

- Provide a spacecraft, integrate the three Government Furnished (GF) instrument(s), qualify the Observatory, ship the Observatory to the GF payload facility, and support launch and commissioning

- Support interface tests with the GF Mission Operations Element (MOE), train and support operational exercises with the flight operations team
- Support mission systems integration and testing with the ground elements
- Provide and maintain interface, software development, RF, and spacecraft interface simulator
- Provide post-launch support for the first five years of mission life
- Provide optional Spacecraft/Observatory Simulator to the MOC, including integrating the Instrument Simulator(s), and post-launch operational support for years 6 - 10 of the mission.

1.2 Project Mission Schedule and Launch

The mission schedule is shown in Attachment K. The LDCM Spacecraft will be launched from Vandenberg Air Force Base on a Government-provided launch vehicle. The baseline Launch Readiness Date (LRD) is July 28, 2011.

1.3 Instrument(s)

The Government will provide up to three instrument(s) in a sequence to be mutually determined, with the delivery no later than as shown in Attachment F, GFE List.

1.4 Mission Partners

LDCM is a joint undertaking by the National Aeronautics and Space Administration (NASA) and the Department Of the Interior, United States Geological Survey (USGS). The LDCM Observatory will provide the USGS with continuation of three decades of global terrestrial imaging by extending the measurement series previously carried out by the Landsat series of Spacecrafts. The USGS will provide the majority of the LDCM ground system, including science data collection, scheduling, ground stations, and the data processing and archive center, as well as the image collection and planning element. NASA will provide the real-time portion of the ground segment, called the Mission Operations Element (MOE), which will control the LDCM Observatory from the Mission Operations Center (MOC).

1.5 Non-Disclosure Agreements

The Contractor is responsible for executing any Non-Disclosure Agreements the Contractor deems necessary to enable information sharing among the LDCM participating product and support contractors and subcontractors. Any other formal agreements between the Contractor and other LDCM participating contractors relevant to this delivery order will be subject to Government review.

1.6 Terms and Definitions

Throughout this SOW, a product or service provided by "the Government" means the referenced product or service may be provided by a Government contractor.

The LDCM Observatory comprises the Contractor-supplied "Spacecraft" integrated with the GF instrument(s). Throughout this SOW, "Observatory" includes the spacecraft and its support of Observatory functions.

The term "TBS" (To Be Supplied) means that the Government will clarify or supply the missing information, during the course of the Delivery Order (DO). "TBR" (To Be Reviewed) means that the stated information will be reviewed for appropriateness by the Contractor and the Government and the value may be changed prior to final definition by the Government during the course of the Delivery Order. "TBD" (To Be Determined) indicates further research or analysis is needed to determine the information, during the course of the delivery order. "TBP" (To Be Proposed) means the Contractor proposes the information with the Offer submission for Government review and approval. All changes to resolve these "TBX" items will be done through a formal process of configuration change review, approval, and delivery order modification.

The Government has identified several Working Groups to address specific LDCM aspects. A Working Group is a cross-organizational team that meets periodically to address specific mission functions or implementation processes. Working Groups will meet at the lead organization's facility, typically for two days, several times a year, for each group's technical focus or topic. Actions and agreements will be tracked by the Working Group lead. Working Group meetings can be combined with other meetings for more effective use of time and travel, and may be via telecon. No technical direction is given at a Working Group meeting. All changes required to implement solutions resulting from Working Group meetings will be done through a formal process of configuration change review, approval, and delivery order or contract modification by each involved party.

A Technical Interchange Meeting (TIM) is an informal meeting between the Contractor and approximately five to ten Government representatives to discuss a system process or feature. For example, to reach understanding of an operation or analysis, presentation of test results, discuss planned interface changes, plan for an upcoming test, etc. TIMs typically are held at a contractor's facility and typically run no more than two days, and occur monthly. Experts may be dialed-in via telecon. TIMs involving the OLI, TIRS, TSIS, launch vehicle, or MOE developers may be conducted at the spacecraft, or other developer's facilities. Actions are tracked by the TIM organizer. No technical direction is given at a TIM. All changes required to implement solutions resulting from TIMs will be done through a formal process of configuration change review, approval, and delivery order or contract modification by each involved party.

A Peer Review is an informal meeting between Contractor technical leads and two to five Government representatives to provide focused, in-depth technical discussions that support the evolving design and development of a product subsystem or discipline area. The peer review

purpose is to add value and reduce risk through expert knowledge infusion, confirmation of approach, and specific recommendations. A peer review provides a penetrating examination of design, analysis, manufacturing, integration, test and operational details, drawings, processes and data. Peer reviews will be held for each critical subsystem in the weeks prior to a major review as a forum to generate and critique the review material, and also as-needed during the implementation whenever expert involvement is needed, for example, on part, material, test, or process issues. Peer reviews will take place at the Contractor's facility and typically last no more than a day. Actions are tracked by the peer review organizer. No technical direction is given at a peer review.

A Major Review is a meeting held at each major implementation milestone, where information is formally presented to a panel of Government experts and external independent reviewers. These experts and reviewers have the responsibility and authority to recommend next steps such as continue as planned, revise the plan, take corrective actions, provide more information, etc. All Spacecraft Reviews in Section 4.3.1.5.1, Observatory Reviews in Section 4.3.1.5.2 and the Mission Reviews in Section 4.3.1.5.3 are Major Reviews. Major reviews can involve up to 40 Government representatives, and run up to four days. Formal action items are logged and tracked by the Project Office. Technical direction may be forthcoming from a Major Review.

2.0 Scope

The Contractor shall furnish all the necessary personnel, facilities, services, and materials to design, fabricate, integrate, test, and deliver the Spacecraft, integrate and test the Observatory, and support launch and commissioning activities for the Observatory developed under this DO. This work shall be performed in accordance with the requirements of this document and all attachments to the DO.

In accomplishing the development and delivery of the Spacecraft, the Contractor shall:

1. Provide the Spacecraft, including the instrument deck, with demonstrated test performance in accordance with the requirements, and the required quality documentation (Mission Assurance Requirements (MAR) document).

2. Participate in all required reviews (Section 4.3.1.5).

3. Receive the Instrument(s) and related Ground Support Equipment (GSE), integrate them with the Spacecraft and perform Observatory level qualification testing.

4. Provide all required Spacecraft and Observatory mechanical and electrical GSE.

5. Perform Spacecraft and Observatory testing, ground segment compatibility testing, space segment compatibility testing, and pre-launch mission readiness testing with the MOE, MOC and entire ground system, in conjunction with Government and contractor personnel.

6. Train, evaluate, and qualify the flight operations team, and provide user manuals.

7. Ship the integrated Observatory and support equipment to the launch site.

8. Support the launch vehicle mission integration process, including support for:

   a. Coordination with the Launch base and the safety program
   b. Observatory to launch vehicle integration and check-out in GF facilities
   c. Fueling the spacecraft
   d. Transport to the launch site
   e. Pre-flight checks and servicing
   f. Launch vehicle to spacecraft integrated procedures including the launch check list.

9. Provide engineering and management services during launch, early orbit, and activation of the Spacecraft and GF Instruments until on-orbit acceptance and commissioning (approximately 90 days post-launch).

10. Provide and maintain the required Simulators, and demonstrate their performance through pre- and post-delivery acceptance testing, deliver and operate them at designated sites.

11. Under DO option(s) as exercised by the Government, receive the instrument simulator(s) and their related GSE, integrate them with the Spacecraft Simulator and qualify the resulting Observatory Simulator performance at the MOC.

12. Provide continuing post-launch engineering support in one-year increments for up to five years after acceptance.

13. Provide continuing post-launch engineering support for years six through ten under delivery order options as they are exercised by the Government.

3.0 Contract Documentation

Contract documentation includes applicable and reference documents, as described in the following sections.

3.1 Applicable Documents

The documents listed in J- Applicable Documents, apply directly to the performance of the DO to the extent specified herein. These documents establish detailed specifications and the performance and interface requirements necessary for the performance of this DO.

3.2 Reference Documents

The documents listed in Attachment J, Reference Documents, are to be used to support the Contractor's LDCM implementation. They apply to the extent defined herein.

4.0 Work To Be Performed by the Contractor

The work to be performed by the Contractor is defined in the following sections in terms of system implementation, non-standard services, standard services, and delivery order options.

4.1 System Implementation

The Contractor shall produce a specified core system, with the selected options, and the mission-unique modifications required in the DO in accordance with the Spacecraft Requirements Document (SRD), which shall result in a product called the "Spacecraft". The Contractor shall integrate the GF Instrument(s), and qualify the combined Instrument(s) and Spacecraft in accordance with the SRD and Observatory Interface Requirements Document (OIRD), which shall result in a system called the "Observatory".

The system implementation requirements are defined in the following sections in terms of the core system, core system options, and mission-specific standard services.

4.1.1 Core System

The Contractor shall design, build, integrate, test, certify, and functionally qualify a Spacecraft ready for Instrument integration. The Spacecraft shall conform to the requirements in the SRD and OIRD.

4.1.2 Core System Option(s)

This section is intentionally left blank.

4.1.3 Mission-Specific Standard Services (Modifications)

The Contractor shall modify the core system as necessary to meet the requirements in the SRD and OIRD.

4.2 Non-Standard Services

The non-standard services include non-mission-specific non-standard services, non-mission-specific hardware, and LDCM specific non-standard services, as defined in the following sections.

4.2.1 Non-Mission-Specific Non-Standard Services

This section is intentionally left blank.

4.2.2 Non-Mission-Specific Hardware

This section is intentionally left blank.

4.2.3 LDCM-Specific Non-Standard Services

Non-standard services specific to LDCM are defined here in terms of resident office services and facilities, special studies, electronic distribution, video conferencing, and data rights.

4.2.3.1 Resident Office Services and Facilities

The Contractor shall provide office accommodations for three full time LDCM Project Office representatives at the Spacecraft manufacturing facility. These accommodations are required to support the LDCM Project Office throughout the DO.

The Contractor shall provide office accommodations for three personnel from each of the LDCM Instrument teams during the period of Observatory integration and test, through launch. The accommodations shall be in the vicinity of the Instrument GSE to facilitate their day-to-day activities, and located outside the clean room.

The Contractor shall provide office accommodations for three Flight Operations Team personnel during the period of spacecraft integration and test. The period of time for the FOT members shall coincide with the start of box-level integration of their assigned subsystem(s) and shall end at the completion of integration of the subsystem to the spacecraft. The Contractor shall provide workspace accommodations for one FOT member during the period of Observatory I&T.

Workspace accommodations shall include, but not be limited to, facilities to support in-plant representatives at the spacecraft development and build site, including securable office space, furniture, facsimile machine, office supplies, file and storage areas, telephones, network access to the Contractor's electronic database, and access to a copier and a dedicated conference room, from contract award through Observatory on-orbit acceptance. The Contractor shall provide within these offices direct-dial long-distance telephone access, high-speed (broadband) internet access and access to an ISP (Internet Service Provider) outside the Contractor's facility to allow access to the GSFC and USGS network.

4.2.3.2 Special Studies

LDCM special studies will be issued by the Government and annually capped in maximum hours or funds for Contractor efforts in assessments, analysis, trades, and similar activities in areas that are not known at this point in the mission.

The Contractor shall perform special studies relating to the development, implementation, characterization, qualification, and operation of the Observatory, as authorized by the Government, and in accordance with contract clause I.A.1 - RATES FOR NON-STANDARD SERVICES (modified to include special studies, rates and ordering procedures for the LDCM Mission as specified in Attachment H, Changes to Baseline RSDO Contract Terms, Conditions and Clauses).

4.2.3.3 Electronic Distribution

To the maximum extent possible, the Contractor shall distribute CDRL deliverables and other LDCM documentation to the LDCM Project Office electronically. The Contractor shall provide a signed hard copy cover sheet for each CDRL item, invoice, modification, etc. for the contract file.

The Contractor shall provide a web-based, password-protected capability to facilitate the communication of information between the Contractor and the integrated LDCM Project Team. Deliverable information generated during the DO shall be placed on this web-site in addition to the formal delivery of these items as specified in the CDRL, Attachment D.

4.2.3.4 Video Conferencing

The Contractor shall have regular access to an on-site video conference facility. The Contractor shall conduct videoconferences with the LDCM Project Office as requested.

4.2.3.5 Data Rights

Data rights shall be in accordance with I.A.23. The Contractor shall make every effort to identify only that information which is proprietary, and shall be prepared to justify any such claim. Generic status charts, agendas, schedules, and the CDRL items are not expected to be proprietary.

4.3 Standard Services

The LDCM standard services the contractor shall provide include program management, systems engineering, Spacecraft implementation, Spacecraft and Observatory integration and test, launch and operations, flight software development and simulators.

4.3.1 Program Management

The Program Management requirements are given in terms of control and reporting, quality management system, quality assurance requirements, documentation, and reviews.

4.3.1.1 Control and Reporting

The Contractor shall provide a program management function that controls all the effort described in this DO. The Contractor's Program Management function shall provide to the Government reporting and at least weekly insight into program status, as well as technical and programmatic performance of all of the Contractor's responsibilities performed under this DO. Schedule reporting shall be in accordance with CDRL 2, Integrated Master Schedule. The Contractor shall prepare and submit monthly and weekly status reports in accordance with CDRL 1.

The Contractor shall perform various design, study, trade-off and analysis tasks relating to the

development, implementation, characterization and operation of the Observatory as necessary.

The Contractor shall submit and negotiate all change order proposals as required under this DO in accordance with the Contract and CDRL 3, Engineering Change Proposals, Deviations and Waivers.

The Contractor shall implement appropriate management systems that prevent the improper dissemination of Government-provided competition sensitive and proprietary information.

4.3.1.2 Quality Management System

The Contractor shall maintain and adhere to a Quality Management System compliant to ANSI/ASQ Q9001-2000, or as modified by the Contractor and agreed to by the Government.

4.3.1.3 Mission Assurance Requirements

The Contractor shall comply with the requirements in the Mission Assurance Requirements (MAR) document. The Contractor shall prepare and provide the following documentation as prescribed by the MAR:

1. Mission Assurance Implementation Plan and Quality Documentation in accordance with CDRL 75

2. Observatory Contamination/Cleanliness Control Plan as described in CDRL 28.

3. Non-Conformance Reports as described in CDRL 30.

4. GIDEP Alert Responses as described in CDRL 31.

5. As-Designed/As-Built Parts, Materials, Processes, and Lubrications Lists as described in CDRL 27.

6. Material Review Board Decisions on Non-Conformances as described in CDRL 30.

7. Failure Modes and Effects Analysis, Fault Tree Analysis and Critical Items List as described in CDRL 36

8. Probabilistic Risk Assessment as described in CDRL 35.

4.3.1.4 Documentation

The Contractor shall develop, produce, deliver, and maintain all documentation required by the CDRLs and necessary to implement the DO. All efforts including the performance of tests and analyses not otherwise explicitly stated in other parts of this SOW, but determined jointly by the Contractor and the Government to be mission critical, shall be performed and documented by

the Contractor. All documentation, data, and analyses generated for, or applicable to, the effort, whether formal or informal, shall be made available to the Government upon request.

The Contractor shall prepare and provide Engineering Change Proposals (ECPs), deviations and waivers as described in the CDRL 3. The Contractor shall provide a Specification Tree in accordance with CDRL 4. The Contractor shall provide Engineering Drawings and Changes in accordance with CDRL 11.

The Contractor shall generate and archive real-time and playback files of a typical day's image data in accordance with CDRL 26, as requested by the Project Office, comprising in-situ instrument science data APIDs gathered during Observatory testing with the instrument(s), as they would be transmitted to the International Cooperators, and also as transmitted to the LGN. The intent is for ground segment personnel to use the files to represent the downlink science digital data flow as it would be seen, recovered from the RF downlink at a ground station, with all the spacecraft science frame formatting including science-like data from the instrument(s) (not spacecraft fill bits), in accordance with the OIRD. The Government intends to use these files in Mission Readiness Testing to support functional and interface verification. The Contractor shall provide each real-time playback file on appropriate media within two days of the request.

The Contractor shall archive, ancillary, and housekeeping data generated by the spacecraft and instrument(s) from the beginning of Observatory integration and test through on-orbit acceptance, as well as selected science data generated by the instrument(s).

The Contractor shall submit a Final Report and Lessons Learned in accordance with CDRL 5.

4.3.1.5 Reviews

All of the reviews, with the exception of the Kick-Off Meeting, the Monthly Status Reviews, the Weekly Status Teleconferences, and Engineering Peer Reviews, will be chaired by the Government. The Contractor shall provide a review data package containing appropriate reference documentation for each review. The minutes and action items that result from these reviews shall be documented by the Contractor and made available to the Government. If any deficiencies are found at the reviews, the Contractor shall be required to develop a corrective action plan. The Contractor may proceed prior to approval of the action plan at its own risk. The Contractor shall present at each review the status of all open action items up to that point in the implementation, with the corrective action or resolution for each item.

The guidelines for all spacecraft and mission reviews are on-line for reference at **http://arioch.gsfc.nasa.gov/301/html/design.html**

The Contractor shall support the spacecraft, Observatory, and Mission-level reviews described in the following sections, and shall submit the required material as specified in CDRL 7, Design Review Data Package.

4.3.1.5.1 Spacecraft Reviews Requirements

The Contractor shall host the reviews in Table 4.3-1, presenting and discussing the subject matter appropriate for each review as specified in CDRL 7. The plan dates shown are notional, and will be re-assessed after all the LDCM participants are known.

TABLE 4.3-1
SPACECRAFT LEVEL REVIEWS

REVIEW	WHEN	WHERE	DAYS	CDRL
Spacecraft Kick-Off	ARO + 1 week	Contractor	1	n/a
Spacecraft SCR	ARO + TBP mos	Contractor	3	7A
Spacecraft PDR	ARO + TBP mos	Contractor	3	7B
Spacecraft CDR	ARO + TBP mos	Contractor	3	7C
Instrument Integration Readiness	ARO + 28 months	Contractor	2	7D
Test Readiness Reviews	1 week before test	Contractor	1	54
Monthly Status Review	Monthly	Contractor	0.5	1
Weekly Status Telecon	Weekly	Telecon	0.1	1
Working Group Meetings	20 per year	Contractor	≤ 2	n/a
Technical Interchange Meetings	12 per year	Various	≤ 2	n/a
Peer Reviews	12 per year	Contractor	≤ 1	n/a
Mission Integration Working Group	Monthly	Telecon	0.1	n/a

4.3.1.5.1.1 Spacecraft Kick-Off Review Requirements

The Contractor shall present for review the plans, schedules, and activities required to meet the delivery order. The agenda and information to be presented shall be coordinated with the Government prior to the meeting, and will largely be based on the Contractor's offer, updated to reflect any changes since the offer submission, including any directed changes.

4.3.1.5.1.2 Spacecraft System Concept Review Requirements

The Contractor shall conduct a System Concept Review (SCR) to assure that the spacecraft requirements are understood and that the proposed approach will meet these requirements, in accordance with the CDRL 7A. The emphasis shall be on the requirements, how they flow down, the proposed design concept and the definition of the major system interfaces. Detailed interfaces are to be presented at later reviews. The SCR is equivalent to the Spacecraft-System Requirements Review (S-SSR), a review title that may appear in Mission documentation.

4.3.1.5.1.3 Spacecraft Preliminary Design Review Requirements

The Contractor shall conduct a Preliminary Design Review (PDR) describing the current spacecraft design in accordance with the CDRL 7B. The objective of this review is to present

the preliminary status of the drawings, analyses, and engineering model development to show the approach meets the final performance and interface specifications. Preliminary calculations for mechanical loads, stress, torque margins, thermal performance, radiation design, and expected lifetime shall be presented.

The Contractor may identify specific commercially-procured components (e.g solid state recorder) of lesser technology readiness level than the rest of the spacecraft, and request they be reviewed to the same level as the other spacecraft components, but separately in time. If the Government concurs with the request, the Contractor shall present the baseline PDR per this section, and schedule a separate Delta PDR for a detailed review of the component. For the first PDR, the component will be assumed to perform as specified. For the delta review, the spacecraft will be assumed to perform as specified at the PDR, and a detailed presentation made on the component's preliminary design and performance.

4.3.1.5.1.4 Spacecraft Critical Design Review Requirements

The Contractor shall conduct a Critical Design Review (CDR) and shall present a final detailed design using substantially completed drawings, analyses, and breadboard/engineering model evaluation test results to show that the design shall meet the final performance and interface specifications and the required design objectives in accordance with the CDRL 7C. Changes required to the design from the PDR shall also be included. Final calculations for mechanical loads, stress, torque margins, thermal performance, radiation design, power generation and storage, communications architecture, data storage, command and data handling, attitude and orbit control subsystem, and expected lifetime are to be presented. Final software requirements, software design, and updated system performance estimates shall also be presented. Parts selection, de-rating criteria, and screening results, and the results of the Failure Modes and Effects Analyses (FMEAs), Fault Tree Analyses (FTAs) and Probabilistic Risk Assessments (PRAs) are to be presented.

The Contractor may identify specific commercially-procured components (e.g. solid state recorder) of lesser technology readiness level than the rest of the spacecraft, and request they be reviewed to the same level as the other spacecraft components, but separately in time. If the Government concurs with the request, the Contractor shall present the baseline CDR per this section, and schedule a separate Delta CDR for a detailed review of the component. For the first CDR, the component will be assumed to perform as specified. For the delta review, the spacecraft will be assumed to perform as specified at the CDR, and a detailed presentation made on the component's critical design and performance.

4.3.1.5.1.5 Spacecraft Instrument Integration Readiness Review Requirements

The Contractor shall conduct a Spacecraft Instrument Integration Readiness Review (IIRR) prior to beginning integration for each instrument. Successful completion of the IIRR shall result in Government concurrence that the Spacecraft performance is adequate for the beginning of the Instrument integration process, in accordance with the CDRL 7D. All procedures required for integration shall be released or ready for release at the IIRR.

4.3.1.5.1.6 Test Readiness Reviews Requirements

The Contractor shall conduct Test Readiness Reviews (TRRs), for all test events at the spacecraft level and higher, no earlier than one week prior to the start of the subject test. At each TRR the Contractor shall demonstrate that all test planning, facilities, staffing, procedures, GSE, and documentation are ready for the subject test. When testing involves other LDCM contracted elements, the Contractor shall coordinate presentation material with the other review contractors. The Contractor shall present the pre-test configuration and status of the unit to be tested, identify all anomalies, problem reports, deviations, waivers, and could-not-repeats. The Contractor shall submit Observatory Performance and Functional Test Readiness Reviews in accordance with CDRL 54.

4.3.1.5.1.7 Monthly Status Reviews Requirements

The Contractor shall conduct Monthly Status Reviews (MSRs) to review project status in terms of schedule, technical issues, performance (including margin), manpower, and to identify problem areas and assign action items for their solution. To save time and travel, these meetings may be combined with other reviews, videoconferences, or teleconferences at the discretion of the Government. Minutes of these combined meetings with a copy of the review hand-outs shall be submitted as the monthly status report, in accordance with CDRL 1.

4.3.1.5.1.8 Weekly Status Teleconference Requirements

The Contractor shall support Weekly Status Teleconferences throughout the DO. A Weekly Status Teleconference is not required during the week that an MSR is held. The Contractor shall address the following topics as a minimum in the teleconferences in accordance with CDRL 1:

1. Delivery Order activities and plans, and the progress against those plans
2. Review of planned upcoming meetings and events
3. Any communications and correspondence related to the implementation
4. Any anomalies and problem reports generated since the last teleconference
5. Issues and action items.

4.3.1.5.1.9 Working Group Meetings Requirements

The Contractor shall host or attend the following working group meetings, each Working Group meets approximately every four months:

1. Space to Ground & Network Interface Working Group
2. Mission Operations Working Group
3. Systems Engineering Working Group (includes instrument interfaces)
4. Mission Systems I&T Working Group
5. Mission Integration Working Group (MIWG) (annually, led by the launch vehicle contractor)
6. Mission Data Systems Working Group
7. Communications Security (COMSEC) Working Group (bi-annual through IIRR).

There will be approximately 20 Working Group meetings a year, although not all working groups meet regularly nor over the implementation lifetime. For example, the Systems Engineering Working Group will overlap the Mission Systems I&T Working Group by six months, and will then dissolve. Actions and minutes from the working group meetings will be informally tracked by the leader of the particular working group. The Contractor shall support the launch vehicle contractor in closing MIWG action items.

4.3.1.5.1.10 Technical Interchange Meetings Requirements

The Contractor shall convene and support Technical Interchange Meetings (TIMs) with the several LDCM contractors, at the Contractor's facility, and at the Instrumentor facilities, at the mutual consent of the participants. There will be one TIM on the average every month over the course of any year. The Contractor shall inform the Government at least one week in advance of each TIM. The Contractor shall identify and track all actions assigned at TIMs.

4.3.1.5.1.11 Peer Reviews Requirements

The Contractor shall convene peer reviews on mutual consent with the Government's request, to explore and resolve issues related to subsystem design, analysis, and performance. The Government will also request peer reviews on parts, materials, processes, and testing, as needed. The goal of a peer review is to familiarize the participants with all the relevant details, reach consensus on plans, tasks, and solutions, and in general prepare a coherent Contractor-Government position on all relevant elements prior to formal presentation at a major spacecraft, Observatory, or mission review. There will be one Peer Review on the average every month over the course of any year. The Contractor shall identify and track all actions assigned at peer reviews.

4.3.1.5.2 Observatory Reviews Requirements

The Contractor shall attend, support, and host (as designated) the reviews in Table 4.3-2 by presenting and discussing the current spacecraft implementation status.

TABLE 4.3-2
OBSERVATORY LEVEL REVIEWS

REVIEW	WHEN	WHERE	DAYS	CDRL
Observatory PER	Test – 1 month	Contractor	2	7E
Observatory PSR	ARO + 41 months	Contractor	2	7F
Observatory OAR	ARO + 43 months	GSFC	1	7G

4.3.1.5.2.1 Observatory Pre-Environmental Review Requirements

The Contractor shall conduct an Observatory Pre-Environmental Review (PER) to review all hardware and software test configurations, test plans, procedures, facilities and responsibilities to ensure that the environmental testing will proceed in a controlled manner and that all the necessary requirements and procedures are documented and understood, in accordance with CDRL 7E. The PER will be held no later than one month prior to planned exposure to the first

environment. The PER shall be considered complete upon satisfactory closeout of PER action items critical to proceeding with the tests.

4.3.1.5.2.2 Observatory Pre-Ship Readiness Review Requirements

The Contractor shall conduct an Observatory Pre-Ship Readiness Review (PSRR) to verify and document that the Observatory, Instrument(s), operations system, and flight and ground software are performing in accordance with the SRD and ICDs including all waivers, in accordance with CDRL 7F. The Observatory PSRR shall be considered complete upon satisfactory closeout of all Observatory PSRR action items.

4.3.1.5.2.3 Observatory On-Orbit Acceptance Review Requirements

The Contractor shall support a one-day On-orbit Acceptance Review (OAR) no earlier than 10 days prior to Observatory hand over to verify and document that the Spacecraft and its interfaces are performing in accordance with the SRD and ICDs, and that all other requirements under this DO have been completed, in accordance with CDRL 7G. Instrument performance will be required only to the extent needed to verify spacecraft interface performance, and will be waived in the event of instrument anomalies. The OAR shall be considered complete upon satisfactory closeout of all critical OAR action items.

4.3.1.5.3 Mission Reviews

The Contractor shall attend and support the reviews in Table 4.3-3, presenting and discussing (for approximately one to two hours) the spacecraft and Observatory status, and participating in any other mission discussions and splinter meetings related to the Observatory implementation and test. The material to be presented at each mission review will be a subset of the preceding Spacecraft or Observatory Review material, updated as necessary. The material to be presented at each review will be prepared in coordination with the Government at a Peer Review(s) prior to the Mission Review.

TABLE 4.3-3
MISSION LEVEL REVIEWS

REVIEW	WHEN	WHERE	DAYS	CDRL
Mission Definition Review	ARO + 1 week	GSFC	3	7V
OLI Instrument PDR	March, 2008	Instrumentor	4	n/a
TIRS Instrument PDR	ARO + TBD	Instrumentor	4	n/a
TSIS Instrument PDR	ARO + TBD	Instrumentor	4	n/a
Mission PDR	SC PDR + 1 month	GSFC	4	7H
Confirmation Readiness Review	June 15, 2008	GSFC	4	7I
MOE System Requirements Review/PDR	Summer, 2008	TBD	3	n/a
Mission Confirmation Review	December, 2008	GSFC	3	7J

REVIEW	WHEN	WHERE	DAYS	CDRL
Ground System PDR	ARO + TBD	USGS EROS	3	n/a
Mission PDR	October, 2008	GSFC	3	n/a
OLI Instrument CDR	September, 2008	Instrumentor	3	n/a
TIRS Instrument CDR	ARO + TBD	Instrumentor	3	n/a
TSIS Instrument CDR	ARO + TBD	Instrumentor	3	n/a
MOE CDR	Fall 2008	TBD	1	n/a
Ground System CDR	ARO + TBD	USGS EROS	3	n/a
Mission CDR	SC CDR + 1 month	GSFC	3	7K
Mission Operations Review	October, 2009	GSFC	3	7L
Ground System Integration Readiness Rvw	ARO + TBD	GSFC	3	n/a
OLI Instrument PER	November, 2009	Instrumentor	3	n/a
TIRS Instrument PER	ARO + TBD	Instrumentor	3	n/a
TSIS Instrument PER	ARO + TBD	Instrumentor	3	n/a
System Integration Review	June, 2010	GSFC	3	7M
OLI Instrument PSR	September, 2010	Instrumentor	3	n/a
TIRS Instrument PSR	ARO + TBD	Instrumentor	3	n/a
TSIS Instrument PSR	ARO + TBD	Instrumentor	3	n/a
Flight Operations Review	February, 2011	GSFC	4	7N
Operations Readiness Review	March, 2011	GSFC	4	7O
Mission Readiness Review	May, 2011	GSFC	4	7P
Safety & Mission Success Review	June, 2011	GSFC	3	7Q
Flight Readiness Review	July, 2011	VAFB	1	7R
Launch Readiness Review	July, 2011	VAFB	1	7S
Post Launch Assessment Review	September, 2011	GSFC	3	7T
Critical Events Readiness Review	September, 2011	GSFC	4	7U

4.3.1.6 Audits

The Contractor shall support Government audits of processes, products, rates, documentation and data in order to provide assurance to the Government that the program is being implemented according to all requirements and specifications. These audits will be invoked by the Government, performed by Government personnel and coordinated with the Contractor to ensure minimal delay and impact on the LDCM implementation. The Government intends to execute at least one mission assurance compliance audit before ARO + 6 months.

4.3.1.7 Government Insight

All Contractor and subcontractor internal technical or mission assurance reviews, audits, meetings and other activities pertinent to the execution of the DO shall be open to Government review and attendance. The Contractor shall provide the Government with 48 hours notification, to facilitate Government attendance. The Contractor may proceed with all activities at their own risk, after Government notification, if the Government chooses not to attend. Government support contractors may also attend these reviews, audits, and meetings at the Government's discretion.

The Contractor shall ensure that all documentation and executable LDCM-specific code required for the NASA Software Independent Verification and Validation (IV&V) effort is made available to NASA IV&V personnel. Wherever possible, the Contractor shall permit electronic access to the required information. The Contractor shall allow NASA IV&V review and participation before final product delivery to the Government.

All Contractor-internal documentation related to the design, build, test, and support of the LDCM spacecraft shall be available to the Government, upon request. The Contractor shall make this documentation available to the on-site representations, or deliverable to the Government in accordance with CDRL 10, Contractor Internal Data, as requested. This documentation does not include sensitive Contractor internal information.

4.3.2 Systems Engineering

The Contractor shall perform the necessary systems engineering required to ensure that the Observatory and related deliverables meet all of the functional performance, interface, and implementation requirements. The systems engineering effort shall comprise the analyses of technical requirements, allocation of derived system, Spacecraft, ground system interfaces, and lower level requirements, definition and maintenance of interfaces, verification of all defined and derived requirements, risk management, tradeoff analyses, and configuration control. The systems engineering effort shall be coordinated with the LDCM Project Office systems engineering effort, and shall be ongoing through development and on-orbit activation of the Observatory.

4.3.2.1 Requirements Analysis and Allocations

The Contractor shall conduct complete analyses of the Observatory requirements that fully establish, define, maintain, and control allocations. An updated index of analyses and allocations shall be maintained by the Contractor and documented in the Observatory Level 4 Specification as described in CDRL 8. The results of all analyses shall be made available by the Contractor for Government review at each major program review. The Contractor shall provide a Configuration Item Identification List in accordance with CDRL 36

4.3.2.2 Interface Definition, Verification and Control

Using the results of the analyses and allocations of technical parameters performed in support of the efforts described in section 4.3.2.1, the Contractor shall specify all interfaces not explicitly defined by Government specifications. The Contractor shall then define, document, verify, and control these interfaces for the duration of the contract.

An Observatory Performance Verification plan shall be prepared in accordance with CDRL.50. Models and Analysis shall be documented as described in CDRL 33 and 34. Telemetry and command requirements shall be documented in accordance with the CDRL 22

4.3.2.2.1 Spacecraft - Instrument Interfaces

The Contractor shall perform systems engineering and analysis in support of designing,

documenting, and implementing all interfaces between the Spacecraft subsystems and the Instrument(s), and Spacecraft GSE-to-Instrument GSE. This support shall include:

1. Generating and maintaining configuration management of the Spacecraft-Instrument interface control documents in accordance with CDRL 13A, 13B, and 13C.

2. Addressing Instrument accommodations and status as part of each Spacecraft review.

3. Identifying cognizant engineer(s) responsible for the Spacecraft interface to the Instrument(s).

   Providing technical support for interface design, documentation, and verification.

4. Performing mechanical, thermal, power, contamination, radiation shielding, jitter, alignment, pointing, and other analyses as necessary to ensure Spacecraft to Instrument compatibility, in accordance with CDRL 34.

5. Attend the Instrument reviews during their implementation prior to Instrument deliveries.

4.3.2.2.1.1 Reduced Thermal Math Models

Reduced Thermal Math Models (RTMMs) of the Instrument(s) will be supplied by the Government for use in defining the Spacecraft-Instrument interfaces in accordance with the CDRL 33. The Contractor shall combine the Instrument RTMMs with the analytical models of the Spacecraft to create a system level thermal model of the Observatory. The Contractor shall create a table of environmental backloads with the Observatory model for distribution to the Instrument teams in order to verify that the Contractor's independent modeling correctly reflects the integration into the Spacecraft's thermal environment. This process is iterative and shall be provided to the Instrument teams one month prior to CDR, PER, and PSR

4.3.2.2.1.2 Finite Element Models

In addition, NASTRAN Finite Element Models (FEMs) of each Instrument will be supplied by the Government for use in designing the Observatory. The Contractor shall combine the Instrument FEMs with the Spacecraft FEM to form an integrated comprehensive Observatory FEM for launch and on-orbit configurations, and shall provide the Observatory FEM to the Government for coupled load analyses by the launch vehicle provider in accordance with the CDRL 33. After completion of the coupled loads analysis, the Government will provide the results of the coupled loads analysis to the Contractor. The Contractor shall provide to the Government the Instrument-related results from the coupled loads analysis. The Government will then provide appropriate information to the Instrument(s) relating to launch loads.

4.3.2.2.2 Spacecraft – Ground Interface

The Contractor shall prepare a Space Segment to LGN ICD in accordance with the CDRL 13E. The Contractor shall work closely with Government mission engineers to ensure the system design meets all of the specified mission requirements.

The Contractor shall prepare a Space Segment to NGN ICD in accordance with the CDRL 13G. The Contractor shall work closely with Government mission engineers to ensure the system design meets all of the specified mission requirements.

The Contractor shall prepare a Space Segment to SN ICD in accordance with the CDRL 13D. The Contractor shall work closely with Government mission engineers to ensure the system design meets all of the specified mission requirements.

The Contractor shall prepare a Space Segment to IC ICD in accordance with the CDRL 13H. The Contractor shall work closely with Government mission engineers to ensure the system design meets all of the specified mission requirements.

The Contractor shall prepare a Space Segment to Programmable Telemetry Processor (PTP)/MOE ICD in accordance with the CDRL 13F. The Contractor shall work closely with Government mission engineers to ensure the system design meets all of the specified mission requirements. The ICD shall include the Observatory to PTP/MOE interface and the spacecraft GSE to PTP/MOE interface.

The Contractor shall perform all analyses and tests required to ensure proper operational compatibility between the Observatory and the Government-provided ground segments. The Contractor shall develop, maintain, and provide all technical and programmatic documentation required to ensure successful operation of the Observatory, including the requirements outlined in the Spacecraft User's Manual CDRL 9 and the Flight Activation Operations Plan as described in CDRL 25.

4.3.2.2.3 Spacecraft – Launch Vehicle Interface

The Contractor shall submit launch vehicle documentation in accordance with CDRL 14. In addition, the Contractor shall participate in the preparation and maintenance of the Observatory-to-LV ICD. The responsibility for writing and maintaining this ICD will reside with the Government. The Government will obtain concurrence from the Spacecraft and Launch Vehicle contractors prior to approving the ICD.

A flight ready mechanical fit check and an electrical interface verification test of the Observatory to the launch vehicle interface shall be performed by the Contractor prior to the final flight mate to launch vehicle interfaces. The mechanical fit check and electrical interface verification test shall be performed at the Contractor's location prior to shipment to the launch site. The Government (or launch services provider) shall supply a test payload attach fitting which simulates the launch vehicle side of the interface.

The Contractor shall provide the analytical models and shall perform all analyses and tests required to ensure proper electrical, mechanical, thermal, and operational compatibility between the Observatory and the Government-provided launch vehicle and its environments. The Government, through the launch service provider, will provide for two cycles of Coupled Loads Analysis. The Contractor shall develop, maintain, and provide all technical and programmatic documentation including the Observatory Launch Site Operations and Test Plan, CDRL 16.

4.3.2.3 Design and Performance Verification Analysis

The Contractor shall perform and document all analyses of the data and information from the design, qualification testing, acceptance testing, compatibility testing, on-orbit testing of the Contractor's hardware and software which are required to ensure that the program will meet its specifications and requirements. The Contactor shall acquire trend data to allow the evaluation of all critical functions, and shall analyze these data to demonstrate system integrity throughout the Spacecraft and Observatory test programs in accordance with CDRL 12.

The Contractor shall provide Anomaly Reports and Trend Analysis in accordance with CDRL 42, item k.

The Contractor shall provide Problem/Failure Reports in accordance with CDRL 30.

4.3.2.4 Safety

The Contractor shall plan and conduct an Observatory system safety program that:

1. Identifies and controls hazards to personnel, facilities, support equipment, and flight systems during all stages of development and integration. The program shall also include hazards in the flight hardware, software, associated equipment, and potential malfunctions in instrument GSE that may affect the Spacecraft or the launch vehicle. The Contractor shall provide a Preliminary Hazard Analysis in accordance with CDRL 41.

2. Satisfies the applicable guidelines, constraints, and requirements in AFSPCMAN 91-710 (Volumes 1 – 3, and 5-7), as tailored for LDCM by the MIWG.

3. Interfaces effectively with the contract industrial safety requirements and the Contractor's own existing safety program. The Contractor shall provide a System Safety Program Plan in accordance with CDRL 42.

The Contractor shall submit the Missile System Pre-launch Safety Package (MSPSP) in accordance with the CDRL 49. The Contractor shall submit Safety Noncompliance Requests in accordance with the CDRL 30.

The Contractor shall submit the Debris Generation Analysis Report in accordance with the CDRL 48. The Government will dispose of the LDCM Observatory at its end of life by controlled re-entry.

The contractor shall provide a pre-launch LDCM Mishap Notification Plan in accordance with the CDRL 47.

The Contractor shall provide Operations Hazard Analysis and Procedures in accordance with CDRL 41.

The Contractor shall provide a Safety Requirements Compliance Checklist in accordance with CDRL 49, item 1.

4.3.3 Spacecraft Implementation

The Contractor's responsibilities for spacecraft implementation are given in the following sections in terms of the spacecraft, flight software development, simulators, GSE, and contamination control.

4.3.3.1 Spacecraft

The Contractor shall design, build and verify a Spacecraft that meets all of the requirements, specifications, and interfaces in accordance with the SRD, IRDs and the ICDs. The Contractor shall submit a Materials and Processes List in accordance with CDRL 29.

The Contractor shall submit a Previously Qualified Hardware and Software Report in accordance with CDRL 74.

Prior to Instrument integration, the Contractor shall conduct a successful comprehensive performance test to demonstrate readiness for Observatory level integration.

The Contractor shall comply with all applicable sections of NPR 2810.1, Security of Information Technology in development, integration, and testing of the Spacecraft.

The OLI instrument will not accommodate mounting any spacecraft hardware.

4.3.3.2 COMSEC

The Contractor shall comply with all applicable communication security (COMSEC) requirements related to the development, integration, and testing of Spacecraft command decryption and authentication capabilities, compliant with NSA/CSS Policy Manual No. 3-16 Issued 5 August, 2005. The Contractor shall maintain a NSA-certified COMSEC account to support the development of command decryption and authentication capabilities.

The Contractor shall implement NSA-approved Caribou decryption and authentication in equipment and physical form.

NSA will supply the keying material for all COMSEC units, flight, GSE, and ground. Delivery of keying material shall be contingent upon NSA approval of the LDCM Key Management Plan.

The Contractor shall review and provide input to the LDCM Key Management Plan consistent with CDRL 67.

The contractor shall produce all documentation required by the NSA for the design, verification, certification, shipment, management, and flight of the COMSEC system, including the design and verification of any secure bypass system and the flight software which controls any COMSEC function. This documentation shall include at a minimum the In-Process Accounting Procedures Plan (CDRL 68), Configuration Audit (CDRL 70), Security Verification Plan (CDRL 71), Security Verification Report (CDRL 72), and the Theory of Design and Operation (CDRL 73).

The contractor shall conduct all required testing required by the NSA, both for the initial certification and to address any issues that may arise following certification, including rework of any relevant hardware or software.

The contractor shall maintain a list of all classified documents generated or held under this DO. Security violations shall be reported to NASA within 48 hours. Defense Security Service (DSS) or other government agency findings or direction applicable to Program activities shall be reported to NASA monthly.

Any deviations or waivers to the government security requirements or the National Security Agency's (NSA) requirements shall be approved by the Government.

A program security indoctrination meeting shall be conducted, with participation from government security representatives. A splinter meeting on the COMSEC implementation and certification process shall be conducted. This meeting and its splinter shall be conducted under the aegis of the COMSEC Working Group.

4.3.3.3 Flight Software Development

The requirements for flight software development are defined in the following sections in terms of software requirements, development, verification, and testing, software maintenance, and software development and maintenance system.

The Contractor shall treat the software component of firmware, which consists of computer programs and data loaded into a class of memory that cannot be dynamically modified by the computer during processing (e.g., programmable read-only memories, programmable logic arrays, digital signal processors, etc.), as software for the purposes of this SOW.

The Contractor shall support the Government's Independent Verification and Validation (IV&V) function by providing access to the flight software, and supporting flight software TIMs with the IV&V team.. The Contractor shall review and assess all NASA IV&V findings and recommendations, and shall forward this assessment of the findings and recommendations to the Government, including the Contractor's position on all recommended corrections. The

Contractor shall appoint a single point of contact to support the IV&V personnel, as required, for analysis, questions, clarifications, and status meetings.

The requirements for flight software development are defined in the following sections in terms of software requirements, development, verification, and testing, software maintenance, and software development and maintenance system.

4.3.3.3.1 Software Requirements, Development, Verification, and Testing

The Contractor shall perform all analyses and systems engineering required to allocate requirements from system and subsystem requirements, and identify software requirements, develop the necessary design specifications for the Spacecraft, and test all software. Software requirements traceability to system and subsystem requirements shall be provided in a traceability matrix. The Contractor shall also describe the documentation system, source code generation and use, and the methods of maintaining software development equipment.

Requirements, design, and code walkthroughs/inspections shall be conducted at the Contractor's facility at the appropriate software developmental life-cycle phase to ensure the correctness of the requirements, design, and source code. These walkthroughs/inspections shall be open to Government participation. The coding, debugging, and developer testing efforts, the results of the walk-throughs, and programmer's notes shall be documented and available at the Contractor's facility for Government review.

The Contractor shall provide all the resources necessary to verify and validate all the software developed for the Spacecraft.

4.3.3.3.2 Software Maintenance

The Contractor shall maintain the flight software and documentation to ensure reliability, maintainability and operability, along with the environments, emulators, and test software necessary to develop, modify, and verify these systems until on-orbit acceptance of the Spacecraft.

The Contractor shall define, with Government concurrence, the portions of flight software that will be maintained by the FOT during on-orbit operations (e.g. table loads). The FOT will facilitate efficient and effective mission operations. The Contractor shall maintain those portions so designated.

4.3.3.3.3 Software Development and Verification Facility

The Contractor shall develop, certify, and maintain a near real-time closed loop flight Software Development and Verification Facility (SDVF), The Contractor shall keep the SDVF at their facility for the duration of the contract period. The Contractor shall develop and deliver SDVF documentation in accordance with CDRL 60C, Simulator Requirements Document, 61C Simulator I&T Plan, 63C Simulator User's Guide, and 64C Training Plan and Materials.

The Contractor shall maintain all unique non-commercial hardware (e.g. C&DH avionics flight computers) in the SDVF for the duration of the contract.

4.3.3.4 Simulators

The use of simulators greatly reduces the risk of incompatibility between the Spacecraft and the other LDCM elements with which it interfaces. The requirements for the Spacecraft Interface Simulator are defined in the following sections.

4.3.3.4.1 Spacecraft Interface Simulator

The Contractor shall provide a spacecraft interface simulator for the Spacecraft-Instrument interface. The Government will provide a Programmable Telemetry Processor (PTP) to interface with the MOE. The requirements for these two types of simulators are defined in the following paragraphs.

4.3.3.4.1.1 Spacecraft Interface Simulator

The Contractor shall provide one Spacecraft Interface Simulator (SIS) for use at the Instrumentor's facility for interface verification during Instrument development. The simulator shall simulate bi-directional command and telemetry interfaces, including all serial, discrete, ground, return, and power interfaces. The connecting hardware shall be certified for use with flight hardware via flight-quality electrical interface to the instrument. The Simulator shall be certified for use in a flight hardware development facility. The Contractor shall make the SIS available at each Instrument developer's facility for two test events that will occur nominally 18 months and 6 months prior to Instrument deliveries. The Contractor shall provide one week of SIS operations support, as well as user's documentation in accordance with CDRL 63 for each of these tests.

The Contractor shall provide a spacecraft interface simulator which verifies the instrument interface performance. The spacecraft interface simulator shall:

1. Generate and route all instrument commands across the appropriate interface

2. Receive, validate, and store all instrument telemetry across the appropriate interface

3. Serve as MIL-STD-1553 bus controller

4. Have sufficient software processing to validate command and telemetry operations, process instrument housekeeping data, and route instrument "science" data.

The SIS will be used to verify instrument and spacecraft procedures, proof-out the wiring connectivity, validate the grounding between the systems, apply the database, and familiarize the parties with each other's integration and test approaches. Spacecraft commands to be executed by the instrument include power on, power off, safing, no-op, initial scripts, and mode changes. Telemetry processing shall include validation and limit checking. The Contractor shall provide the documentation to define the performance requirements, plan the I&T, report

the acceptance testing results, user's guide, and training plan and materials, in accordance with CDRLs 60A, 61A, 62A, 63A, 64A.

4.3.3.4.1.2 GF Programmable Telemetry Processor

The Government will provide a Programmable Telemetry Processor (PTP) to interface between the Spacecraft GSE and the MOE, to support the spacecraft command and telemetry traffic with the MOE. The Simulator will provide digital signaling at its interface to communicate with the spacecraft GSE, similar to the demodulated clock and data signals between the spacecraft and the LGN.

4.3.3.5 Ground Support Equipment

The Contractor shall provide the Ground Support Equipment (GSE) to integrate, test, and verify the Spacecraft and Observatory.

The Government will deliver the Instrument(s) to the Observatory integration and test site. The Government will also provide the Instrument ground support equipment (IGSE) and software (flight and embedded IGSE) necessary to support testing of the Instrument(s) at the Observatory level. The Contractor shall provide the accommodations for the Instrument electrical and mechanical GSE and Instrument stimuli and targets, as defined in the respective Instrument ICD. Instrumentor equipment to be used in thermal-vacuum testing will be certified for chamber use.

The Contractor shall provide an S-band roof-top antenna system, compatible with TDRSS, at the Contractor's I&T facility to support Spacecraft, Observatory, system, and operations tests.

4.3.3.6 Contamination Control

The Contractor shall assure appropriate contamination control is maintained throughout all phases of integration and test. The Contractor shall maintain and demonstrate the cleanliness levels specified in the OIRD.

The Contractor shall provide an Observatory Contamination/Cleanliness Control Plan coordinated with the Instrument contamination control requirements, in accordance with the CDRL 28.

4.3.4 Spacecraft and Observatory Integration and Test

The Contractor shall integrate and test all Spacecraft and Instrument interface hardware and software for performance and for Spacecraft and Instrument compatibility at the Observatory level. The Observatory shall be tested with calibrated and maintained GSE, and shall be compatibility tested with the ground control system in accordance with the Mission Integration and Test Plan. The Instruments will not perform calibration operations as part of Observatory I&T.

The Contractor shall prepare a Spacecraft and Observatory Integration and Test plan in accordance with CDRL 56A.

The Contractor shall perform an interface test to demonstrate the Observatory to ground downlink feed meets the OIRD requirements.

The Contractor shall provide the Government digital copies of all photographs and video recordings made during integration, testing, and close-outs, in accordance with the CDRL 6.

The Contractor shall provide support facilities for the Instrument Providers to use for flight delivery, unpacking, lifting and handling, and bench checkout activities. The Contractor shall provide basic cleaning supplies and standard calibrated instrumentation (e.g. digital volt/amp meters, oscilloscopes), as requested. The Instrumentors will provide their own tools and test cables.

The Contractor shall be responsible for monitoring and reporting the instrument health and safety at all times any instrument is powered. The Contractor shall maintain a safe environment for the instrument, the Instrumentor personnel, and the associated GSE from the time they are delivered to the spacecraft facility through Observatory delivery to the launch site payload processing facility.

The Instrumentor will be responsible for all physical contact with the Instrument up to the time the Contractor's lifting equipment touches the Instrument lift hardware. The Contractor shall be responsible for all physical contact with the Instrument from the time the Contractor's lifting equipment touches the Instrument lift hardware (i.e. "On-Hook"), and for the Instrument mechanical safe-keeping, until the Instrument is removed from the spacecraft or the Observatory launches.

The Contractor shall inform the Project Office of all regular and ad-hoc I&T meetings, and coordinate phone access to allow the Government to participate via telecon.

The Government will provide a Programmable Telemetry Processor (PTP) which will provide the format and timing conversions required to interface the Contractor's spacecraft GSE to the MOE. In all ground testing involving the MOE, the Contractor's GSE and the Spacecraft Simulator will interface to the GF PTP.

The Contractor shall provide facility support for the MOE/PTP and the resident FOT members, during Observatory I&T. The Contractor shall provide telemetry connectivity to the MOE/PTP for FOT members to monitor I&T activities throughout spacecraft I&T. The Contractor shall enable the FOT to monitor and participate in a non-interference basis in Spacecraft and Observatory testing of, for example, flight software, attitude control, command and data handling, etc.

The Contractor shall support PTP access to the spacecraft and instrument telemetry at all time the spacecraft is powered.

4.3.4.1 Spacecraft and Observatory Integration

The Contractor shall plan and conduct integration of the Spacecraft and Instrument(s). The Contractor shall develop integrated Observatory test procedures in coordination with the Instrument providers. The Contractor shall develop the detailed test requirements in conjunction with the Instrument suppliers as part of interface development and documentation. After Instrument integration, all tests shall be conducted through the Spacecraft and its associated GSE (i.e., Spacecraft GSE to Spacecraft to Instrument(s)). Real-time monitoring of Instrument command and telemetry shall be made available to Instrumentor analysts supporting the Observatory system level testing. The Contractor shall provide all Instrument test data to Instrumentor analysts, in mutually agreed upon format and media after completion of testing. Except to support anomaly resolution, the Instrumentor GSE will not be connected to the Instrument after Spacecraft integration. The Contractor shall submit Spacecraft and Observatory Integration and Test Procedures in accordance with CDRL 57.

The Contractor shall provide a "Quick Look" status as-needed during, and at the completion of each test activity, to indicate whether a preliminary assessment of the test data indicates the test is progressing successfully, and whether the Contractor recommends the test continue, or that the test configuration can be struck and move on to the next activity. The "Quick Look" shall include all instrument status from the Instrument Provider relevant to the test activity.

The Contractor shall provide an automated system that logs and tracks the generation, status, and closure of all anomalies that occur during Spacecraft and Observatory integration and test. I&T anomalies shall include at a minimum any failures, problems, and concerns affecting I&T (e.g. unanticipated or unsatisfactory performance of the spacecraft, instrument(s), facilities, personnel, GSE, procedures, materials, etc.). The Contractor shall generate weekly reports showing the content and status of any and all anomalies.

The contractor shall provide all relevant test data and anomaly reports to each Instrument Provider as needed.

The contractor shall incorporate all troubleshooting, recursion testing, repair, etc. information from any Instrumentor regarding instrument anomaly resolution in the process of closing anomaly reports. Testing beyond the scope of the Contractor's approved Observatory I&T Plan will be performed under equitable adjustments to the DO implemented prior to the testing.

4.3.4.2 Spacecraft and Observatory Test

The Contractor shall plan, manage and execute Spacecraft and Observatory interface and performance verification, system testing, and environmental testing in accordance with the Mission Integration and Test Plan, and in the LEVR. The Contractor shall submit a System Environmental Verification Plan and Matrix in accordance with CDRL 51. The Contractor's integration and test program shall include, as a minimum:

1. Electrical interface testing performed prior to integration of any assembly, component or subsystem into the next higher assembly. As a minimum, pin-out configuration, impedance, and power and signal characteristics shall be verified.

2. Performance testing shall be performed as the last test activity prior to and the first test activity after the environmental test program. Performance testing shall verify, to the maximum extent possible, 100% functionality of all components including redundant systems, as applicable. An Observatory CPT shall be run prior to the PER to establish the baseline performance. The pre-ship CPT shall be run following exposure to all environments, and its results compared with the pre-test baseline. Exceptions to this flow shall be coordinated with, and approved by, the Government. The Contractor shall submit Observatory Performance and Functional Test Plans in accordance with CDRL 52. The Contractor shall submit Observatory Performance and Functional Test Procedures in accordance with CDRL 53.

3. Functional testing shall be performed prior to and as soon as practicable following structural testing. The Contractor shall submit Observatory Performance and Functional Test Reports in accordance with CDRL 55.

4. Electromagnetic Interference and Compatibility Environmental testing, appropriate for the Spacecraft offered, shall be performed to demonstrate self compatibility between the Spacecraft and instrument(s). Compatibility with the launch vehicle and launch site as defined by the applicable specifications for each shall also be demonstrated.

5. Thermal vacuum environmental testing, appropriate for the Spacecraft offered, shall be performed to demonstrate that all Spacecraft and Instrument components function properly in their intended operational environment. Performance testing shall b e performed during thermal-vacuum testing. Representative thermal balance and orbital power simulation tests shall be run in this environment as well. Thermal vacuum environmental testing shall be the last environment in the test flow.

6. A set of environmental tests, as specified in the LDCM Environmental Verification Requirements (LEVR), to verify Spacecraft and component performance under the expected structural loads, vibro-acoustics limits, sine vibration limits, mechanical shock limits (including solar array release and launch ring separation), during all phases of the LDCM mission.

The Contractor shall ensure that at no time shall any test (functional and environmental) expose the Instrument(s) to environments, signals, or other conditions that exceed the limits specified in the Contractor's Spacecraft to Instrument ICDs.

The Contractor shall support the mission readiness testing defined in paragraph 4.3.4.2.2. The mission readiness testing will be conducted by the Mission Operations Manager, and executed using the MOE/PTP and the Mission Operations Center, to verify Spacecraft compatibility with the ground system hardware and software.

The Contractor shall provide a Mass Properties Report in accordance with CDRL 32.

The Contractor shall provide complete written justification for each analysis the Contractor chooses to perform in lieu of test, for review and approval by the Government.

The Contractor shall provide complete written justification for each environmental test the Contractor proposes not to perform, for review and approval by the Government.

The Contractor shall perform functional, baseline performance, electrical, electromagnetic, and interface verification of the integrated Observatory, including RF compatibility van testing, prior to initiating environmental testing. The Contractor shall verify the Observatory requirements, as documented in the SRD, using one or more methods (analysis, inspection, demonstration, or test) as selected by the Contractor and defined in the Contractor's Spacecraft and Observatory Integration and Test Plan in accordance with CDRL 56A.

In addition to test plan definition, the Contractor shall generate all test procedures, test reports, success criteria, test tools and resources to conduct the Observatory verification. The Contractor shall conduct any pre-test set-up as necessary and define the detailed schedule and dependencies for the execution of the identified tests. Observatory test requirements are detailed in the LEVR. All devices to be powered-on at launch shall be powered-on during vibration environment testing, and their performance continually monitored to document uninterrupted operation.

The Contractor shall perform all necessary tasks to verify Observatory function and performance with all interfaces, including the PTP/MOE, LDCM Ground Network, Space Network, and NASA Ground Network. The Contractor shall verify Observatory outputs, format and contents, directly with the interfaces or with Contractor-provided simulator(s) and GSE. The Contractor shall schedule and coordinate all resources required to execute the tests to complete the I&T Plan.

The Contractor shall perform a final comprehensive performance test prior to preparation and shipment of the Observatory to the launch site.

Spacecraft Contractor support for ground system interface compatibility and mission readiness testing is described in the following paragraphs.

4.3.4.2.1 Ground System Interface Compatibility

The Contractor shall provide a spacecraft compatible with the ground systems as specified in the OIRD.

The Contractor shall provide support to the Government mission engineers and participate in communications, command, control and operational requirements trade analyses in the working groups.

The Contractor shall provide all necessary interfaces between the GSE and the Government-provided network interface, for connectivity to the MOC. This shall include all necessary system documentation, interface control documents, databases and test efforts.

The Contractor shall support MOE/PTP interface tests for early confirmation of the data flows, formats, and contents as specified in the OIRD. To support these tests, the Contractor shall provide the command and telemetry list and handbook in accordance with CDRL 22 and the command and telemetry database compliant with the GF Data Format Control Document and in accordance with CDRL 23. The Government will establish and maintain the LDCM Project Database (PDB) in an XML format, compliant with the LDCM Data Format Control Document (DFCD), which will combine spacecraft, instrument(s), and ground system command and telemetry databases, and other database information required to operate and maintain the observatory and ground system in a common format. The Contractor shall support the Government development of the DFCD. If the Contractor's database is not in an XML format, the Government will provide a translator. The Contractor shall accept and implement Government-provided deliveries or updates of the LDCM Project Database every 3 months beginning after integration of the spacecraft command and data handling system to the spacecraft bus. The Contractor shall also receive ad-hoc updates or patches as needed. The Government will verify any translations from MOE Contractor-provided database inputs to the LDCM Project Database. The Contractor shall verify any translations from LDCM Project Database.

4.3.4.2.2 Mission Readiness Testing

The Mission Readiness Testing (MRT) is performed to certify the ability of the Observatory and Ground System to operate as required to meet mission performance requirements, assessing their performance and their interfaces in various operational environments.

The Contractor shall support the LDCM integrated test team to plan coordinate, and execute the MRTs. The Government will facilitate the test working group sessions in preparation for test execution. The Contractor shall provide detailed test procedures based on the mutually defined test steps to accomplish the test objectives and shall coordinate with the Government for generation of test procedures for the MRT. The Contractor shall provide all necessary information, including the command and telemetry database, command procedures, and expected results from the spacecraft perspective. The Contractor shall support test execution with engineering support personnel in attendance at the MOC. The Contractor will have final approval of the spacecraft test procedures and will be capable of halting the test should the need arise. The Contractor shall perform any pre-test setup and check out as necessary to ensure readiness of the MRTs. The Contractor shall be responsible for reviewing and approving the procedures to be executed for the MRTs.

The six MRTs are defined in the following tables. The Contractor shall support all six test activities.

MRT 1		
Test Objectives	**Target Time**	**Brief Description**

	Frame	
▪ Evaluate space segment and ground system integration ▪ Demonstrate operations structure and functionality in a "test as you fly" environment ▪ Repeat routine and periodic mission operations under varying conditions ▪ Ground segment configuration, spacecraft acquisition, state of health assessment, solid state recorder management and termination ▪ Stored command management	10 - 9 mos. prior to launch	Day In The Life – routine and periodic operations. MRT 1 provides the basis for subsequent tests. All routine and periodic mission operations are executed repetitively under varying conditions. Routine operations are executed daily by the on-line controllers and require no special support. Periodic operations are executed by the on-line controllers with less frequency than routine operations and require no special support.

MRT 1 is expected to run in one day, excluding any setup or other supporting test activities. The test configuration may include hard-wire or RF connection to the spacecraft.

MRT 2		
Test Objectives	**Target Time Frame**	**Brief Description**
▪ Verify contingency plans ▪ Test all plans to the extent possible with the spacecraft ▪ All sequences planned and known in advance ▪ Ground and spacecraft contingencies are executed ▪ Verify contingency responses	9 - 8 mos. prior to launch	Contingency operations. MRT 2 simulates a variety of anomalous interconnectivity behaviors. The FOT will detect, diagnose, and resolve the anomalies. Selected ground and spacecraft contingencies will be executed and verified.

MRT 2 is expected to run in two days, excluding any setup or other supporting test activities. The test configuration may include hard-wire or RF connection to the spacecraft

MRT 3		
Test Objectives	**Target Time Frame**	**Brief Description**
▪ Demonstrate acceptable performance in special activities ▪ Flight software and special SSR management commands ▪ Selected launch and early orbit and contingency procedures ▪ May be performed in TVAC	8 - 7 mos. prior to launch	Special operations. MRT 3 includes those activities which require engineering support to supplement the on-line controllers. All planned special operations except maneuver will be executed. FOT systems

		engineering provides support.

MRT 3 is expected to run in two days, excluding any setup or other supporting test activities. The test configuration may include hard-wire or RF connection to the spacecraft

MRT 4		
Test Objectives	**Target Time Frame**	**Brief Description**
▪ Demonstrates the ability to coordinate, execute and verify maneuvers ▪ Maneuvers include altitude and orbit adjusts ▪ Contingency procedures will be executed.	7 - 6 mos. prior to launch	Maneuver operations. MRT 4 is the most complex operation the FOT performs. Simulates the entire maneuver sequence from planning through post analysis. Support comes from the FOT and systems engineering.

MRT 4 is expected to run in two days, excluding any setup or other supporting test activities. The test configuration may include hard-wire or RF connection to the spacecraft

MRT 5		
Test Objectives	**Target Time Frame**	**Brief Description**
▪ Demonstrates image collection, processing and analysis ▪ FOT performs all routine and periodic operations including validation data collection, processing, and distribution	6 – 5 mos. prior to launch	Instrument operations. MRT 5 concentrates on all activities supporting science data collection, processing and analysis. The resulting data is provided to the Science Team for analysis.

MRT 5 is expected to run in three days, excluding any setup or other supporting test activities. The test configuration may include hard-wire or RF connection to the spacecraft. MRT 5 can be run during Observatory thermal-vacuum testing.

MRT 6		
Test Objectives	**Target Time Frame**	**Brief Description**
▪ Demonstrate long-term autonomous operations ▪ Runs over one integral Operating Period (~72 hours) ▪ FOT performs planned off-line activities ▪ Mission planning is off-line using	5 - 4 mos. prior to launch	Scheduling Period In The Life. MRT 6 executes over the basic ground segment cycle, including integral stored command load period with overlap. The overlap allows for the spacecraft configuration, two transitions

MOE and CAPE		between schedule periods, and completing data collection, processing and analysis.

MRT 6 is expected to run in four days, excluding any setup or other supporting test activities. The test configuration may include hard-wire or RF connection to the spacecraft.

4.3.4.3 Spacecraft, Observatory, and GSE Shipping, Handling and Transportation

The Contractor shall be responsible for the shipment of the Observatory between the place of manufacture and integration with Instrument(s), and the launch facility. The Contractor shall provide all necessary shipping and storage containers, cables, documentation, and consumables needed for shipment. The Contractor shall provide for the shipment of necessary GSE required to support the Spacecraft or Observatory during each phase of test, integration, and launch preparation, including the Instrument GSE. The Contractor shall prepare the Observatory Transportation and Handling Plan and Procedures in accordance with CDRL 58. The Government will be responsible for the planning, preparation, packing, and shipment of the Instrument(s)' GSE after launch.

The Contractor shall obtain any necessary shipping permits and hazardous material exemptions, as required. During all shipments the Contractor shall perform continuous monitoring of the shipping and handling environment for all controlled conditions (shock, temperature, air cleanliness, air or nitrogen purge, and humidity) while the Observatory is in the shipping container.

The Contractor shall reassemble, as required, check out, and certify all Contractor GSE after each shipment, verifying that they are all operating within normal specification limits before their use with the Spacecraft/Observatory. All hardware shall comply with the seismic safety requirements of AFSCMAN 91-179, Vol 3, Chapter 17.

The Government will disassemble, reassemble, check out, and certify the Instrument GSE.

4.3.5 Launch and Operations

Launch and operations includes launch support, flight operations interfaces support, on-orbit performance verification, and on-orbit engineering support, as defined in the following sections.

The Government will provide the launch vehicle and the Payload Processing Facilities near the launch pad.

4.3.5.1 Launch Support

The Contractor shall support launch mission integration, analyses and test, and operations, in accordance with the following paragraphs.

4.3.5.1.1 Launch Mission Integration Support

The Contractor shall provide management and engineering support for all Observatory activities associated with the launch vehicle and launch services. These activities include but are not limited to: systems integration, interface definitions, interface verification, Observatory to launch vehicle integration, ground processing facilities and GSE integration and readiness, and launch support effort. The Contractor shall assure that compatible interfaces between hardware and software are defined, coordinate launch vehicle interface requirements definitions, and support and conduct design and safety reviews, technical interchange meetings, and working group and ad-hoc meetings. The Contractor shall support all activities related to the development of interface documentation and provide concurrence that all requirements have been satisfactorily implemented by the Government-provided launch services contractor. The Contractor shall provide a Launch Site Support Plan in accordance with CDRL 15.

4.3.5.1.2 Launch Analytic and Test Support

The Contractor shall provide management and engineering support for all analytic efforts conducted by the Government-provided launch services contractor necessary for the assessment of launch vehicle environments, interfaces, and ground processing on the Spacecraft design. This support includes development of detailed Observatory analytic models analysis of ground processing facility compatibility, compliance with interface safety requirements, and compatibility with launch vehicle flight environments and flight design. The Government will be responsible for obtaining valid coupled loads analysis results from the launch organization. The Contractor shall compare the results of the coupled loads analysis cycle to the design loads used in Spacecraft structural analyses to confirm that the resulting loads are within the design requirements as specified in the launch vehicle ICD. In addition, the Contractor shall support all MIWGs and tests (e.g., fit checks, shock tests), as required, to ensure that Observatory requirements are satisfied.

4.3.5.1.3 Launch Operations

The Government, in conjunction with the Contractor, will make the final go/no-go decision for launch. The Contractor shall provide all required integration, safety, and engineering support to process the Observatory through the ground processing facilities, launch facility, and the launch vehicle. In addition, this effort shall encompass the Contractor's efforts necessary to support the actual launch, post-launch orbit insertion, perform Spacecraft initialization, deployments, spacecraft certification, support instrument initialization, and preparation for on-orbit performance verification testing. This activity will be under Government direction from launch through separation of the Observatory from the launch vehicle. The Contractor shall provide Launch Commit Criteria in accordance with CDRL 18.

4.3.5.2 Flight Operations Interfaces and Support

The Government will provide ground systems for Observatory operations. The Government furnished flight operations team will be responsible for executing all on-orbit operations procedures for the LDCM Observatory. The Contractor shall conduct the training and initial operations of up to 20 members of the flight operations team, and qualify their ability to operate the Observatory, in accordance with CDRL 65.

The Contractor shall participate in GF MOC training in support of the Contractor's use of the MOC and MOC systems during launch and early operations.

4.3.5.2.1 Launch Site Testing

Following shipment of the Observatory to the launch site, the Observatory will be performance tested, prepared for flight, transported to the launch pad, and mated to the launch vehicle. The Observatory and launch vehicle interface will be verified based on the launch vehicle interface documentation.

The Contractor shall support or perform all tasks necessary to integrate, test, and prepare the Observatory for launch at the launch site. This includes developing Observatory to launch vehicle integration test plans, procedures, and services; check out of interfaces with the launch vehicle and launch facilities; and mission readiness tests involving the Observatory, launch vehicle, and ground system. The Contractor shall support launch site check out, including post-mate telemetry testing of the Observatory communications in the form of loop back tests with the ground support equipment. The Contractor shall demonstrate first motion of all deployable spacecraft assemblies.

The Government will conduct, analyze, and evaluate pre-launch training and simulations of the launch (through orbit insertion). The Contractor shall support and participate in five launch and activation simulations (two at the Contractor's facility and three at the launch site) and three launch rehearsals at the launch site.

4.3.5.2.2 Ground Systems and Flight Operations Team Training

The Contractor shall train the Flight Operations Team for on-orbit initialization, check out, performance verification, and anomaly resolution. The Contractor shall provide the documentation and data required to provide training and logistics support necessary for the training of flight operations personnel at the Contractor's facility. All training presentations shall be video recorded and provided to the Government. The Contractor shall provide the Operations Procedures and Scripts in accordance with CDRL 24 and a Flight Activation Operations Plan as described in CDRL 25.

The Contractor shall provide Observatory related parametric data sufficient to properly configure the mission operations element flight dynamics attitude and orbit services. Pre-launch values provided shall be integrated into the mission operations element by the Flight Operations Team and tested against flight dynamics data provided by the Contractor. Post-launch revised values for applicable parameters shall be provided by the Contractor during On-Orbit Performance Verification.

The Contractor shall support the FOT's production of operational procedures and scripts by providing written operations procedures for launch, early-orbit, activation, commissioning, and nominal operations; participating in TIMs and providing spacecraft expertise on flight

operations. The Contractor shall review, comment, and sign-off on all operational procedures and the operational command and telemetry database prior to launch.

4.3.5.3 On-Orbit Performance Verification

The Contractor shall provide on-orbit performance verification in the areas of on-orbit spacecraft checkout, and Observatory on-orbit checkout, as described in the following sections. Spacecraft Acceptance occurs at successful spacecraft checkout. The on-orbit events include:

1. Launch and ascent, including fairing separation
2. Separation from the launch vehicle
3. Spacecraft initialization
4. On-orbit spacecraft checkout
    a. Spacecraft checkout
    b. Spacecraft Acceptance
5. Observatory checkout
    a. Instrument Checkout(s)
    b. Ground control and systems checkout

These activities are detailed in the following sections.

4.3.5.3.1 On-Orbit Checkout

The Contractor shall perform on-orbit checkout by supporting spacecraft checkout, anomaly resolution and on-orbit acceptance, spacecraft database support, and trending on-orbit parameters, in accordance with the following paragraphs.

4.3.5.3.1.1 Spacecraft Checkout

The Contractor shall support Spacecraft check out and establishing state of health following launch and Observatory separation. The FOT will issue all Observatory commands, with the concurrence of the Contractor, in accordance with the Flight Activation Operations Plan, CDRL 25. The Contractor shall monitor the Observatory telemetry, support on-orbit anomaly investigations, and acquire historical data for trend analysis. Checkout will nominally complete less than 90 days after launch, unless delayed by unresolved spacecraft anomalies.

The Contractor shall provide the on-orbit check out plan in accordance with CDRL 19. The Contractor shall report on-orbit spacecraft performance in accordance with CDRL 20, addressing all pertinent issues affecting mission success.

The Contractor shall assess the FOT's readiness to assume operational control of the Observatory, according to CDRL 65.

The Contractor shall provide system lead and subsystem engineering support at the mission operations center on an around-the-clock basis until all Spacecraft subsystems are activated and checked out, the Observatory is in the mission orbit with all Spacecraft subsystems performing nominally; and 12 hours x 7 days per week coverage through Instrument activation

(approximately 30 days); and 8 hours x 5 days per week until Observatory acceptance by the Government (approximately 90 days). The Contactor shall submit daily status reports through system acceptance by the Government. The Government will provide Instrument check out and operations support during this time.

The Contractor shall provide an Acceptance Data Package in accordance with CDRL 17.

4.3.5.3.1.2 Anomaly Resolution and On-Orbit Acceptance

The Contractor shall resolve all out-of-specification on-orbit performance issues as assigned to the Contractor by the LDCM Project Office. This support shall remain effective until the end of the check out period, or until Spacecraft acceptance by the Government, whichever occurs later. The Contractor shall provide any support required to resolve such pre-acceptance Spacecraft anomalies. This includes support of periodic conference calls on the status of anomalies under investigation.

4.3.5.3.1.3 Spacecraft Database Support

The Contractor shall support database updates by making database corrections, validating them on the software development validation facility, and participating in the uplink transmission, up through Government spacecraft acceptance.

4.3.5.3.1.4 Trending On-Orbit Parameters

The Contractor shall develop an on-orbit Spacecraft engineering trending approach. The Contractor shall identify parameters to trend, including pseudo-parameters, and analyze the data with the intent to identify anomalous performance, out-of-family performance, degradation of components, characterize nominal aging effects, predict EOL, etc. Comparisons shall be made between on-orbit performance and Spacecraft-level pre-launch test data. This approach shall be documented in the Observatory and Operations Description Manual as described in the CDRL 12.

4.3.5.3.2 Observatory Checkout

The Contractor, in conjunction with Instrumentor support, shall support an on-orbit performance verification program to confirm that the Observatory performance is in accordance with the mission requirements, specifications, and interfaces. The LDCM Instrument Operations Team(s) will perform the necessary Instrument testing, in accordance with the following paragraphs.

4.3.5.3.2.1 Observatory On-Orbit Check Out

After the Observatory has reached the operational orbit and deployed/released all appendages/mechanisms, the Contractor, with the support of the Government-provided Flight Operations Team, shall support a check-out to verify the post-launch performance and state-of-health of the Observatory. The Government-provided Flight Operations Team will issue Observatory commands, monitor the Observatory telemetry, support on-orbit anomaly investigations, and acquire historical data for trend analysis. All nominal systems shall be verified for proper function and performance. The check out shall be planned to complete prior to 90 days on-orbit, but may occur later if Spacecraft anomalies are not resolved. The Contractor

shall provide the on-orbit check out plan to the Government in accordance with the On-Orbit Commissioning Plan as described in CDRL 19. The Contractor shall prepare a report that summarizes the on-orbit performance of the Observatory compared to its required performance for the mission after launch. All pertinent issues affecting mission success shall be addressed. The extent of performance explanation required depends on the seriousness of the impacts that any problems identified may have on mission success. The Contractor shall also provide an assessment of the flight operations team's readiness to assume operational control of the Observatory. This report summarizes the Observatory performance on-orbit after launch and check out to determine initial mission success. Government acceptance of the Observatory will occur after the on-orbit check out based upon successful operation of the Observatory as mutually defined and agreed to in the Flight Activation Operations Plan.

4.3.5.3.2.2 Observatory-Ground Control and Data Systems Interface Verification

This effort shall be performed by the Contractor, with the support of the Government-provided Flight Operations Team, after the Observatory on-orbit performance and state-of-health have been confirmed. The purpose of this effort is to verify proper operations of the Observatory to ground system interfaces and to provide the necessary calibrations. The Contractor shall provide support for the 16-day design reference case which the Government will execute as part of Instrument acceptance.

4.3.6 Spacecraft and Observatory Storage

The Contractor shall prepare a Spacecraft and Observatory Storage Plan in accordance with the CDRL 66. This plan will be invoked by the Government in coordination with the Contractor in the event unforeseen LDCM delays occur at the mission level.

4.3.7 Nominal Operations

The Contractor shall provide the following services in five one-year periods over the first five years of mission operations following OAR as part of the core contract delivery order:

1. Management, systems engineering, and administrative support to engineering activities.

2. Prior to the end of the first five years of mission operations, train the Government FSW Maintenance Team on FSW maintenance (e.g. table loads) in preparation for transition of FSW maintenance to the Government.

3. Participate in a joint LDCM Configuration Control Board with the Government. Assume one telecon meeting per month of one-half day duration starting at the end of the commissioning phase.

4. Maintain the SDVF for the duration of the contract, including all unique non-commercial hardware (e.g. C&DH avionics flight computers).

5. Maintain the spacecraft portions of the S/OS at the MOC.

The Contractor shall provide an Operations Transition Plan in accordance with CDRL 21.

4.3.8 Other Required Activities

This section is intentionally left blank.

4.4 Delivery Order Options

The delivery order options for future selection by the Government are defined in the following sections.

4.4.1 OPTION-1 TSIS Accommodation

When the TSIS accommodation option is exercised by the Government, the Contractor shall implement the design approach to accommodate TSIS as presented at the spacecraft PDR, as revised by any post review actions. The Contractor shall implement the mechanical and electrical interface, support the TSIS reviews and meetings in Paragraph 4.3.1.5.3, support Spacecraft Interface Simulator testing, and perform S/OS I&T with the TSIS Instrument Simulator. The Contractor shall perform all the I&T activities described in paragraphs 4.3.4.1 and 4.3.4.2 of this SOW relevant to TSIS, and submit the ICD in accordance with CDRL 13C. When this option is exercised, the Government will extend the LRD 30 days.

This option expires two months following the Spacecraft PDR.

4.4.2 Option-2 TIRS Accommodation

When the TIRS accommodation option is exercised by the Government, the Contractor shall implement the design approach to accommodate TIRS as presented at the spacecraft PDR, as revised by any post review actions. The Contractor shall implement the mechanical and electrical interface, support the TIRS reviews and meetings in Paragraph 4.3.1.5.3, support Spacecraft Interface Simulator testing, and perform S/OS I&T with the TIRS Instrument Simulator. The Contractor shall perform all the I&T activities described in paragraphs 4.3.4.1 and 4.3.4.2 of this SOW relevant to TIRS, and submit the ICD in accordance with CDRL 13B. When this option is exercised, the Government will extend the LRD 30 days.

This option expires two months following the spacecraft PDR.

4.4.3 Option-3 Spacecraft/Observatory Simulator

The Contractor shall develop a Spacecraft/Observatory Simulator for Ground System testing, Flight Operations Team (FOT) training, FOT procedure verification, and anomaly resolution. The Contractor shall develop any Instrument software simulation tools and MOC interface simulations required to verify the Spacecraft Simulator interfaces and its functionality prior to Spacecraft Simulator delivery. The Contractor shall provide the documentation to define the performance requirements, plan the I&T, report the acceptance testing results, user's guide, and training plan and materials, in accordance with CDRLs 60B, 61B, 62B, 63B, 64B.

The Contractor shall provide a S/OS which:

1. Emulates the spacecraft subsystem functions with a fidelity such that the operator sees no significant difference between operating the simulator versus operating the spacecraft

2. Provides flight-like interfaces for the instrument simulators, compliant with the respective instrument ICD

3. Interfaces with the GF Programmable Telemetry Processor (PTP) for functional connectivity with the MOE

4. Supports (when integrated with the GF instrument simulators) Observatory-level operations, ground systems testing, executing scenarios, simulations (including fault injection), FOT training, mission rehearsals, and anomaly resolution

5. Hosts the LDCM flight software, or a high-fidelity emulation of the flight software

6. Operate in near real-time

7. Supports flight and ground software test and certification.

Following acceptance of the Spacecraft Simulator by the Government, the Contractor shall integrate the GF Instrument simulators and, with the support of the Instrumentors, verify the performance of the resulting Spacecraft/Observatory Simulator by running procedures and scripts mutually agreed with the FOT, MOE contractor, and Instrument Provider(s).

The Contractor shall provide facilities for the Instrumentor(s) to deliver, unpack, checkout, and operate the Instrument Simulator(s).

The Contractor shall ship the S/OS to the MOC, assemble and check out its performance as needed, and verify the S/OS performance against the pre-ship baseline.

The Contractor shall support interfacing the S/OS with the MOE/PTP at the MOC, and maintain the S/OS through Observatory commissioning.

The determination to exercise this option will be made at delivery order award.

4.4.4 Option-4 Three-Month Launch Delays (may invoke up to 4 times)

The Contractor shall accommodate a 90 calendar day slip in the delivery schedule for any or all Instrument(s) as indicated in the GFE List, Attachment F, with a concurrent 90 calendar day launch delay. This option will be invoked with at least 60 calendar days' notice prior to the Instrument(s) delivery dates. The Government may exercise any 90-day launch delay in increments from two-weeks to three-months.

4.4.5 Option-5 Extended Operations

When exercised by the Government, the Contractor shall provide the following services in five one-year periods over the second five years of mission operations (i.e. years 6 – 10):

1. Management, systems engineering, and administrative support to engineering support activities

2. Prior to the end of the second five years of mission operations, train the Government FSW Maintenance Team on FSW maintenance in preparation for transition of FSW maintenance to the Government.

3. Participate in a joint LDCM Configuration Control Board with the Government. Assume one telecon meeting per month of one-half day duration starting at the end of the commissioning phase

4. Maintain the SDVF for the second five years of mission operations, including all unique non-commercial hardware (e.g. C&DH avionics flight computers)

5. Maintain the spacecraft portions of the S/OS at the MOC.

The first determination to exercise this option will be made 90 days before the end of the first five years on orbit. Determination for each of the subsequent options will be made 90 days before the end of the preceding operating year.

4.4.6 Option-6 Task Support

The Contractor shall provide 4,000 hours of support related to the continued on-orbit support of LDCM, as authorized by the Government. Each task will be initiated by written direction from the Government contracting officer. The Government will coordinate with the Contractor to define each task in detail, and establish manpower ceilings, performance schedules, and deliverables. For proposal costing purposes, assume a total task support pool of 4,000 hours, extending over the first two years on-orbit.

These Government-initiated tasks include, but are not limited to:

1. Support post-Commissioning operations as required. This support can include: supplying technical expertise to perform analyses, to review data, or to review changes to documentation.

2. Investigate on-orbit anomalies that affect specification-related performance parameters and/or anomalies that threaten Observatory health and safety and provide recommendations for resolution. The Contractor shall acknowledge notification of the anomaly and provide an initial action plan within 12 hours of notification by the Government. The Government will follow up with written direction and coordinate the

task details as soon as possible. An action plan describes the activities intended to support the anomaly investigation.

3. Maintain flight software and provide updates to flight software to provide capabilities requested by the Government. Provide technical documentation, installation procedures, on-orbit validation procedures and back-out procedures.

4. Participate as necessary in the Decommissioning Review prior to decommissioning of the observatory at end-of-life.

The determination to exercise this option will be made 90 days following launch.

4.4.7 Option-7 Observatory Models

Upon the Government's exercise of this option, the Contractor shall provide twenty scale models of the completed Observatory. The delivery dates and scale will be mutually agreed between the Contractor and the Government.

4.5 Acronyms and Abbreviations

All acronyms and abbreviations are described in the LDCM Acronym List and Lexicon referenced in Attachment J, Reference Documents List.